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Integrated Pest Management Guide

Arizona Five-spined Ips, *Ips lecontei* Swaine, in Ponderosa Pine

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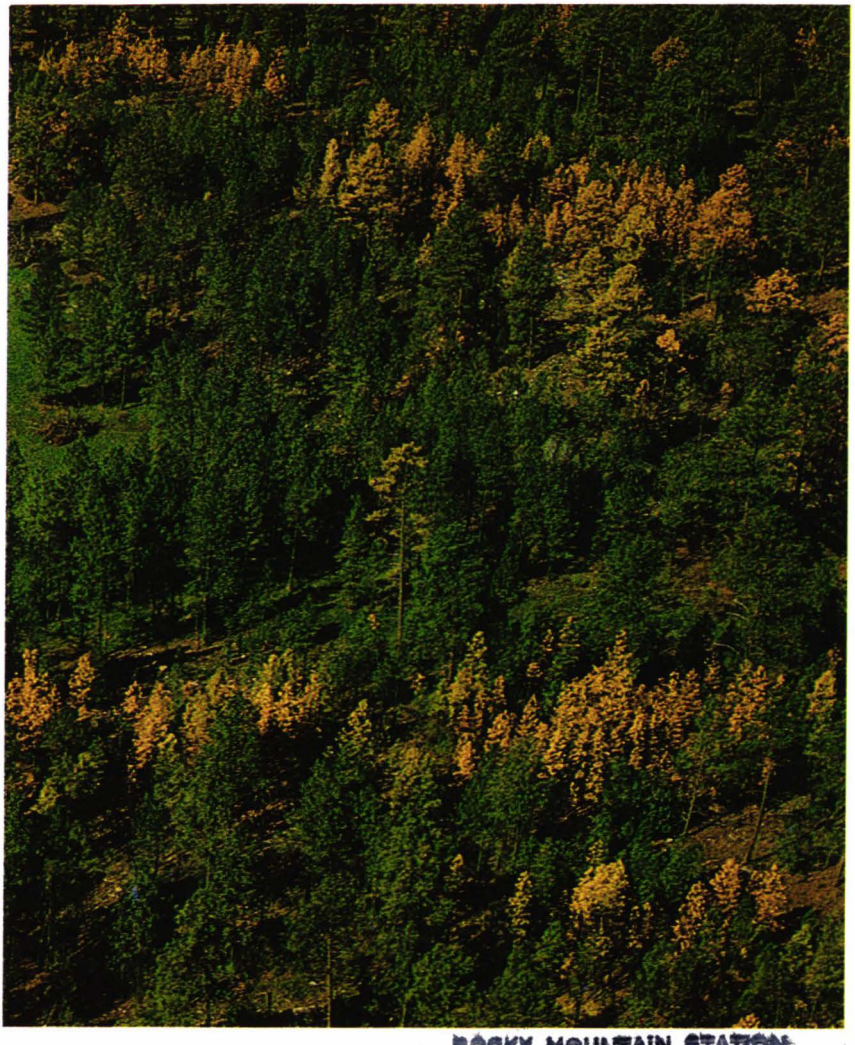
By Douglas L. Parker



ROCKY MOUNTAIN STATION

Introduction

In the past 10 years, the Arizona five-spined ips, *Ips lecontei* Swaine, has become the most destructive forest insect in ponderosa pine forests in central and southern Arizona and southwestern New Mexico (Furniss and Carolin 1977). It has been found that most damaging outbreaks occur as a direct result of a variety of forest management practices that create slash and weaken trees. Beetles attack fresh slash and weakened trees, a population buildup occurs, and live trees are attacked and killed. As forest managers apply more intensive practices in ponderosa pine forests, the potential occurrence of damaging outbreaks will continue to increase unless preventive measures are taken. Thousands of pole-size trees can be killed during severe outbreaks. The loss of trees in management areas can significantly decrease timber production and increase management costs.

Virtually all Arizona five-spined ips-caused tree mortality can be prevented if forest managers understand the reproductive capacity of this beetle, integrate pest management techniques into program planning processes, and use appropriate techniques on a timely basis. When prevention is not feasible, suppression measures may be considered.

This guide summarizes technical information in publications, observations of pest management specialists, and unpublished tree loss data concerning this insect. The primary objective of the guide is to present the most important facts about the beetle and its management, and to serve as a reference tool to the forest manager.

Life History and Habits

Generally, *I. lecontei* goes through three complete generations in a year (Fig. 1). Adult beetles, which have spent the winter under the bark of infested material, emerge when warm weather arrives and search for favorable habitat. They prefer to attack freshly cut slash, but when large numbers of beetles are present, live trees can be attacked and killed. Adults bore through the outer bark, construct galleries, and lay eggs in the soft inner bark. Eggs hatch in about a week and larvae feed upon the inner bark for about 4 weeks before they pupate. Adults develop from the pupae in about a week and emerge by boring out through the bark. They fly to suitable habitat and start the second generation. Due to warmer temperatures in July, the second generation completes development in about a month—less than half the time required to complete the first generation. Another flight occurs and the third generation begins in mid-August. The third generation takes about the same time to develop as the first generation (80 days). Beetles in this generation usually remain under the bark and do not fly until the following spring. At lower elevations on warm sites, third generation adults may fly in the fall and begin a fourth generation.

Drought, pathogens, and other factors that weaken trees favor outbreaks; however, over 80 percent of all outbreaks are primarily caused by slash or weakened trees created during forest management programs (Fig. 2). Typically, beetles attack green slash or weakened trees, a population buildup occurs, and beetles emerge from the slash to attack and kill live trees in or near management areas. The most damaging outbreaks occur when fresh slash and weakened trees are periodically present in an area for two or more years, permitting a massive beetle population buildup. When conditions are right, and there is no additional fresh slash, beetles attack and kill live trees (Fig. 3). Live, healthy trees are not favorable habitat for beetle brood production, and populations usually decline in the next generation. However, high population levels may continue if live trees are stressed by drought or other factors.

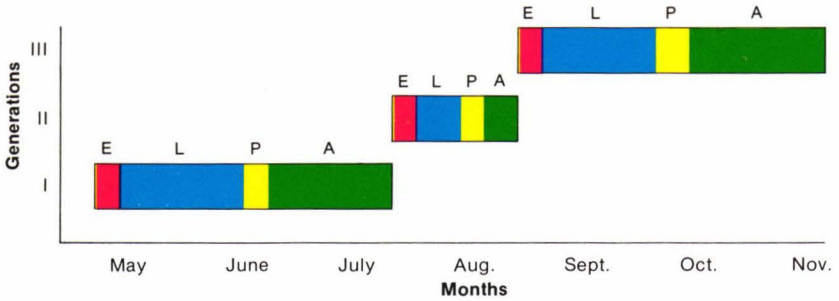


Fig. 1.—The Arizona five-spined ips generally completes three generations each year. For ease of understanding, this graph shows distinct periods for each generation, but generations actually overlap. Beetles go through four stages of development: Egg (E), larva (L), pupa (P), and adult (A).

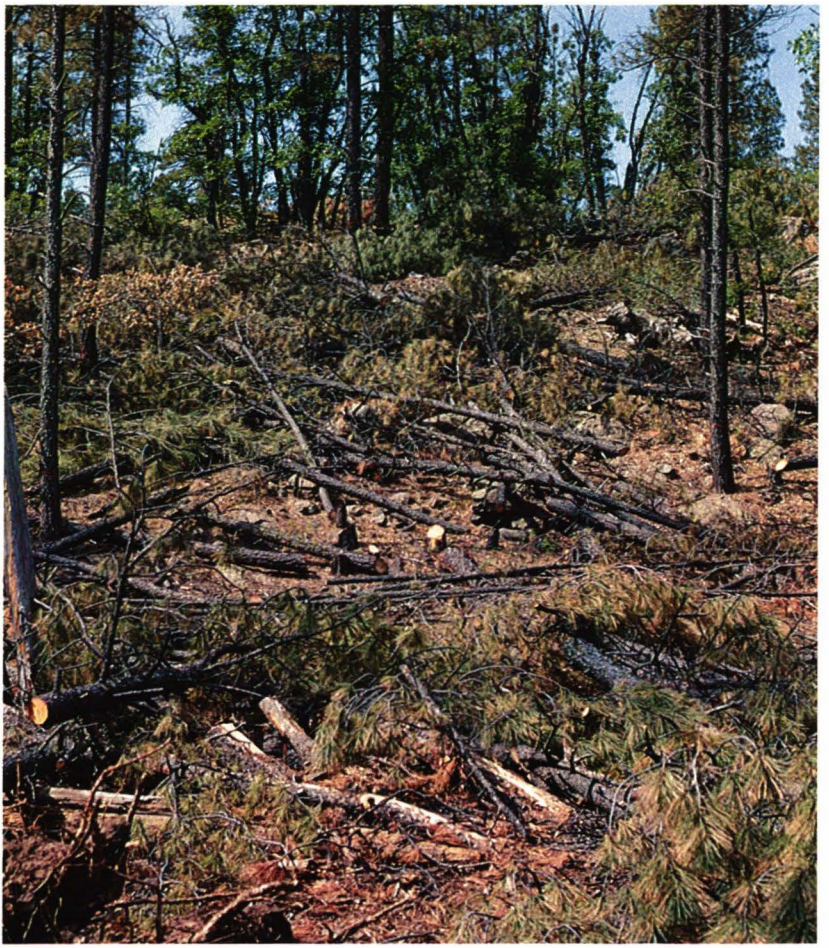


Fig. 2.—Ponderosa pine slash favors outbreaks.

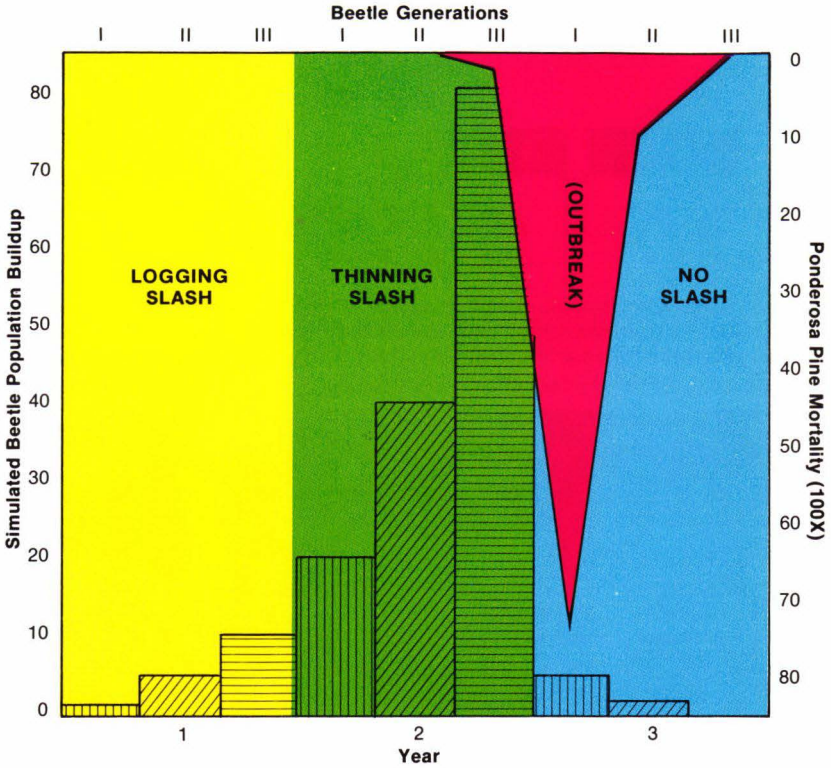


Fig. 3.—A beetle population buildup over a 2-year period and the ensuing outbreak in live trees is simulated above. Fresh ponderosa pine slash was continuously available in years 1 and 2, the beetle population increased to a high level at the end of the second year, a damaging outbreak occurred in year 3, and the beetle population collapsed after live trees were infested.

Evidences of Infestation

Boring Dust

When beetles bore through the outer bark and construct galleries in the inner bark, they produce a fine dust that is tan to reddish brown. This dust or frass is pushed out through the entrance hole and collects in bark crevices and at the base of standing trees (Fig. 4). Rarely, small pitch tubes (globules of pitch) appear in the trunk of infested trees.

Gallery Pattern

The Arizona five-spined ips is a polygamous species. One to five females can join each male, but three is most common (Massey 1971). The male beetle bores through the outer bark, forms a nuptial chamber in the inner bark, and is joined by the females. Each fertilized female then constructs her own egg gallery leading from the nuptial chamber. With three females, the gallery has a characteristic Y-shaped pattern (Fig. 5).

Stages of the Insect

The Arizona five-spined ips goes through four life stages:

Eggs: Eggs are oval, glossy-white, and barely visible to the naked eye (0.5 mm to 1.0 mm long). They are laid in niches on each side of egg galleries.

Larvae: Larvae are white, legless grubs, with light-brown head capsules (Fig. 6). There are three instars or sizes of larvae (Ostmark 1966). Small larvae feed in groups for a short time after hatching, then feed individually, each making a separate tunnel as they develop into medium size and then large larvae. Mature larvae are about 6 mm long, and they construct circular pupal cells in the inner bark and transform into pupae.

Pupae: Pupae are white, about 5 mm long, and have many adult characteristics, such as antennae and wing covers. Pupae gradually darken as they change into adults (Fig. 6).

Adults: Beetles are light brown at first, but darken to black as they mature. They are about half a millimeter long and have five small spines on each side of a declivity (cavity) on their posterior (Fig. 6).

Fading Trees

Within a month after trees have been attacked in the spring, needles in the upper crowns of trees change to a light straw color. Fading continues until all the foliage of the tree becomes yellowish brown (Fig. 7). Sometimes, only the upper portions of a tree are infested and top-killed (Fig. 8), but these trees usually die within 1 to 2 years as a result of additional beetle attacks or other factors. Trees attacked in later summer or in the fall often do not fade until the following spring.

Fig. 4.—Boring dust produced by beetles on slash (top) and standing tree (right).

Fig. 5.—A typical Arizona five-spined ips gallery pattern consists of three egg galleries in a y-shaped pattern radiating from a nuptial chamber shown at the tip of the pencil.

Fig. 6.—An *I. lecontei* Swaine mature larva (left), a pupa (center), and an adult (right).

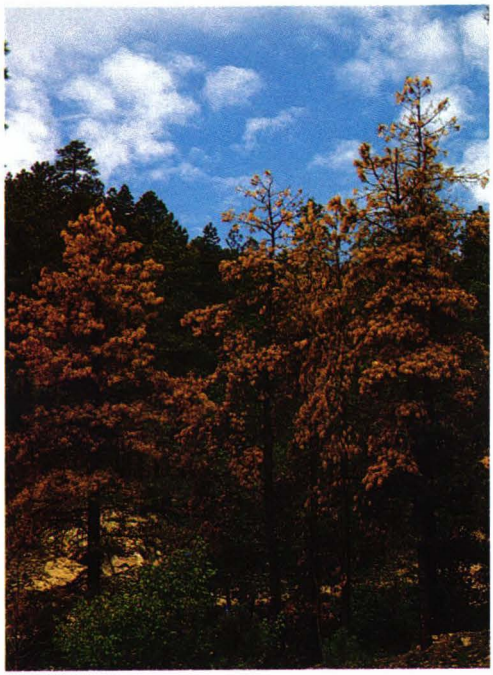


Fig. 7.—Faded trees killed by the Arizona five-spined ips.

Fig. 8.—Trees top-killed by *I. lecontei.*

Effects of Infestation

There is considerable variation in the amount of tree-killing that occurs during *I. lecontei* outbreaks. Sometimes, only a few groups of trees are attacked and killed by beetles emerging from slash, while on other occasions, populations of apparently similar proportions kill thousands of trees. The factors that influence the amount of tree-killing are not well understood, and most cannot be assessed, but it is generally known that severe outbreaks occur when beetle populations increase in slash for two or more years.

To show what can occur during a typical outbreak, the results of a survey conducted at a location in central Arizona to assess tree losses are presented. The infestation occurred in an almost pure ponderosa pine forest where recent logging and thinning slash had been present for a period of 2 years. The outbreak was first detected when forest workers noticed groups of pole-size trees beginning to fade from green to yellow. A few weeks later, 65 groups of dead trees over a gross area of about 7,000 acres, ranging in size from an estimated 30 to 300 trees, were located during an aerial survey. A complete ground survey was done in 14 of these infestation centers to determine: 1) the number and size of beetle-killed and top-killed trees, and 2) the number and size of remaining trees.

The survey revealed that the Arizona five-spined ips seriously depleted stands in all infestation centers. Overall, 2,129 trees were killed on 12.1 acres within the 14 infestation centers checked (Table 1). The average loss was 176 trees per acre. Depletion of stands in sampled areas varied from 80 to 99 percent of all trees 3 inches in diameter at breast height (d.b.h.) and larger, and the average loss was 91 percent. Seventy-nine percent of the dead trees were less than 9 inches d.b.h. (Table 2). Sawtimber trees were also killed by *I. lecontei* in association with other *Ips* species, the red turpentine beetle, *Dendroctonus valens* LeConte, and the western pine beetle, *Dendroctonus brevicomis* LeConte.

Few trees 3 inches in diameter and larger survived the beetle outbreak within infestation centers (Fig. 9). The number of live

trees remaining averaged 17.4 trees per acre (Table 1). Tree survival averaged 9 percent.

An infestation in a ponderosa pine stand can have significant economic effects. The following "ball park" estimates are provided to show the loss in revenues for future timber production and increased expenditures for timber management for the example area (7000 acres).

1. *Reforestation expenditure.* Trees may have to be planted on sites capable of producing commercial timber where tree stocking was reduced below an acceptable level. Planting costs could be as high as $14,625: 65 (infestation centers) X 0.9 (average acreage per infestation center) = 58.5 (acres affected) X $250 (planting cost per acre) = $14,625.

2. *Merchantable volume loss.* It is assumed that dead trees will not be salvaged because they are too scattered, inaccessible, or checking of the wood would occur before logging could be accomplished. The value of the merchantable volume lost would be $32,468: 58.5 (acres affected) X 37 (average number of dead trees per acre 9.0 inches in diameter and larger) X 100 (estimated average board foot per tree) X $0.15 (value per board foot) + $32,468.

3. *Growth loss.* The value of growth loss for trees killed by the beetle could be as high or greater than $2,168: 58.5 (acres affected) X 0.91 (average stand depletion rate) X 20 (minimum cubic foot growth that would occur per acre per year on productive commercial forest land) X $0.75 (value per cubic foot) X 50 (years until next logging entry) = $39,926; discounted for 50 years at 6 percent, the current value would be $2,168.

4. *Total timber value and expenditures.* The total dollar value related to the beetle infestation is calculated at $49,261: — planting costs + volume loss value + growth loss value = $49,261.

Table 1.—Tally of beetle-killed and live trees in 14 selected infestation centers, Arizona, 1978.

Infestation center	Acreage	Total dead trees[a]	Percent dead trees	Total live trees	Percent live trees	Total trees per center
1	2.9	274	85	47	15	321
2	1.5	374	90	40	10	414
3	0.3	134	85	24	15	158
4	0.8	219	98	4	2	223
5	0.2	115	95	6	5	121
6	0.2	52	80	13	20	65
7	0.4	90	98	2	2	92
8	0.7	97	99	1	1	98
9	0.2	45	96	2	4	47
10	1.9	176	95	9	5	185
11	1.5	274	93	22	7	296
12	0.3	89	87	13	13	102
13	0.9	62	94	4	6	66
14	0.3	128	83	26	17	154
Total	12.1	2,129	91	213	9	2,342

[a]Top-killed trees are included in this category.

Table 2.—Tally of beetle-killed and top-killed trees by 1-inch diameter classes.

Infestation center	Diameter[a] of dead and top-killed trees											Total trees
	3	4	5	6	7	8	9	10	11	12	13	
1	17	38	42	42	20	30	25	17	15	9	19	274
2	66	73	72	53	32	27	24	8	6	1	12	374
3	29	32	20	23	16	4	4	3	0	1	2	134
4	46	47	32	31	22	15	10	3	4	2	7	219
5	41	16	14	12	10	10	4	3	3	0	2	115
6	1	0	5	14	7	8	5	7	2	1	2	52
7	12	17	17	12	10	9	6	3	3	0	1	90
8	17	16	13	11	8	5	9	8	4	2	4	97
9	5	6	5	6	5	3	4	1	5	4	1	45
10	33	27	27	16	14	16	16	9	3	2	13	176
11	43	46	43	33	29	17	16	11	12	9	15	274
12	15	13	13	6	4	9	3	7	4	5	10	89
13	5	5	5	7	9	7	7	7	3	1	6	62
14	32	16	14	10	20	5	6	8	3	5	9	128
Total	362	352	322	276	206	165	139	95	67	42	103	2,129
%	17	16	15	13	10	8	7	4	3	2	5	100

[a]3 inch class = 3.1–4.0; 4 inch class = 4.1–5.0; etc.

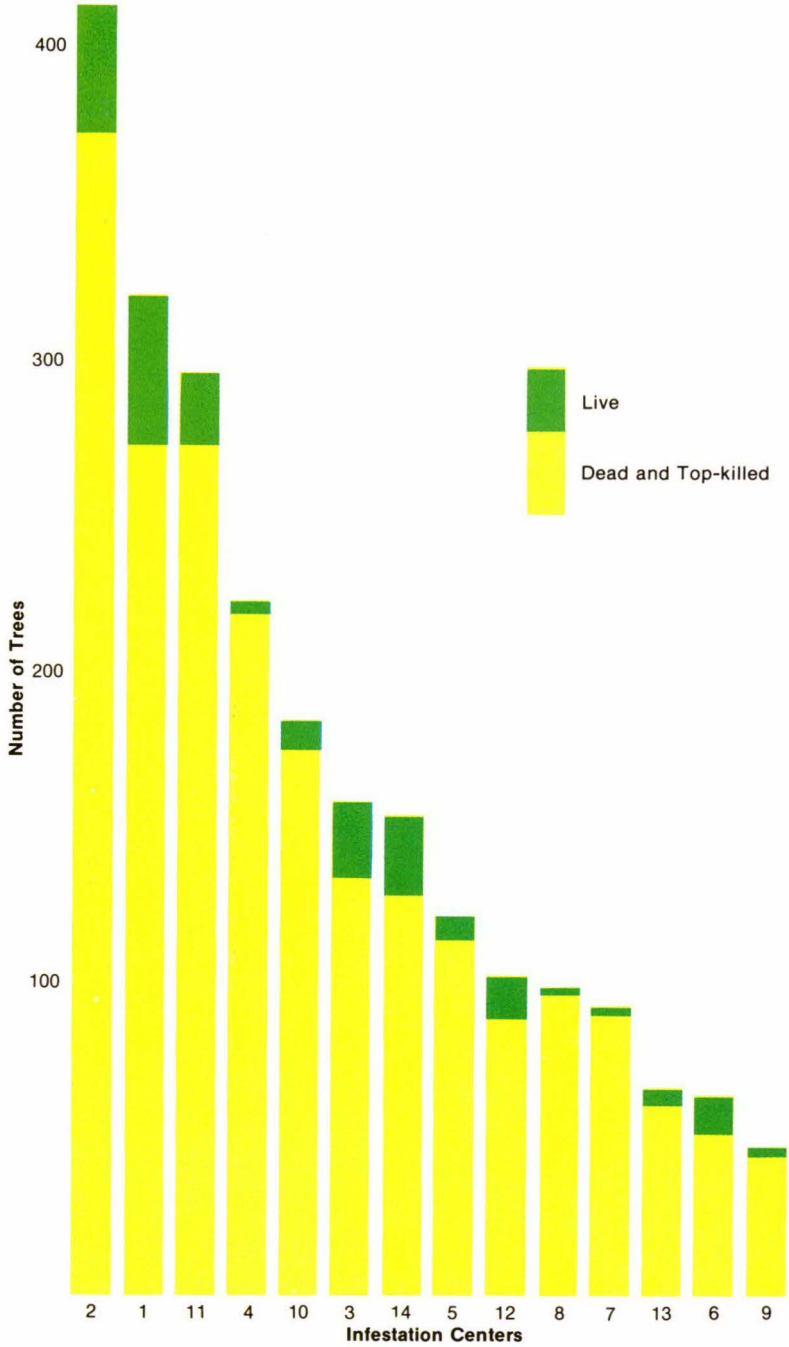


Fig. 9.—Number of live trees and dead and top-killed trees are shown for the 14 infestation centers sampled.

Integrated Pest Management

Beetle-caused tree losses can be substantially reduced through the use of one or more prevention and suppression techniques—a concept called integrated pest management. To be effective, forest managers must be familiar with all suitable techniques, consider their use when planning programs, and use them when appropriate and in a timely manner. Prevention is the recommended approach because the techniques are more effective, economical, environmentally acceptable, and compatible with forest management methods. However, it is not always possible to avoid conditions that favor outbreaks, whether they are natural or man-caused, and suppression must be considered. Suppression should be considered as a high-risk decision and should be done only as a last resort.

Prevention

The number and combination of prevention methods needed in a management area must be evaluated in relation to the risk of an outbreak occurring. At a minimum, slash should not be created for more than 1 year in ponderosa pine stands growing at the lower elevational range of the species on the Prescott, Coconino, Tonto, and Apache-Sitgreaves National Forests, San Carlos and Ft. Apache Indian Reservations, and nearby lands of State and private ownership, Arizona; and the Gila National Forest and nearby State and private lands in New Mexico. Additional preventive techniques are recommended for use on the Prescott National Forest where the potential for outbreaks appears to be high due to the prevalence of southwestern dwarf mistletoe, *Arceuthobium vaginatum* supsp. *cryptopodum* (Engelm.) Hawks. and Weins, a disease that weakens trees and favors beetle buildups. Strict prevention measures are needed during droughty periods. Conversely, extra effort on preventive techniques are not recommended in areas where trees are relatively vigorous or where outbreaks rarely occur. A brief discussion of prevention methods follows:

1. *Utilization.* Harvesting most ponderosa pine trees to a 4-inch (10.2 cm) top will prevent beetle population increases. Few beetles are produced in debris below 4 inches in diameter outside bark (d.o.b.) because of the limited amount of food reserve in the inner bark.

2. *Timing of Management Programs.* The season when trees are cut greatly influences the production of beetles in future generations. Trees cut from July to December dry out during the fall and winter and are unfavorable for beetle habitat. It is best to cut trees in mid- to late-summer to permit trees to dry for as long a period of time as possible. The inner bark of green trees cut from January to May usually remains moist and is suitable for beetle habitat.

3. *Avoiding Programs that Create Slash for More than 1 Year.* The chances of causing an outbreak can be greatly reduced by avoiding the practice of creating slash and weakening trees in a management unit for more than a year. A beetle population will remain at a relatively low level if programs are conducted on an every other year schedule. It appears that a buffer of 3 to 5 miles between management areas is sufficient to prevent a mass movement of beetles from one area to another, even though data are not available to support this statement.

4. *Slash Disposal.* Any means of destroying green slash—burning, chipping, burying, or other practices—will remove the conditions favoring beetle buildups.

Suppression

I. lecontei populations can be suppressed if infested slash is treated before beetles emerge and attack live trees. The decision to conduct a costly suppression program is risky because there is no reliable way to determine if beetles will attack live trees in a management unit, fly elsewhere to attack trees, or decline without killing any trees. Also, infestations in slash must be found just after initial attack to allow time to complete administrative procedures needed for funding and to carry out an on-the-ground treatment project. Too often, infestations are not detected by forest workers until live trees have begun to fade. Once this occurs, it is too late to take any action to limit tree losses. Forest workers must know the evidences of infestation, check for infestations in slash on a timely basis, and promptly report the occurrence of outbreaks to pest management specialists. Surveillance work sheets and kits

can be used to report outbreaks, but a direct request for assistance by other forms of communication also is appropriate.

Methods of suppression follow:

1. *Covering Infested Slash with Clear Plastic.* Beetle broods in infested slash (4 inches d.o.b. and larger) can be killed by piling bolts in forest openings, covering piles with clear plastic, and securely anchoring the plastic to the ground (Fig. 10). The plastic covering functions like a greenhouse, and temperatures reach a level high enough to kill beetle broods (Buffam and Lucht 1968). This approach should not be used if beetles have begun to emerge.

2. *Slash Disposal.* Burning, chipping, debarking, or burying infested slash will kill beetle broods.

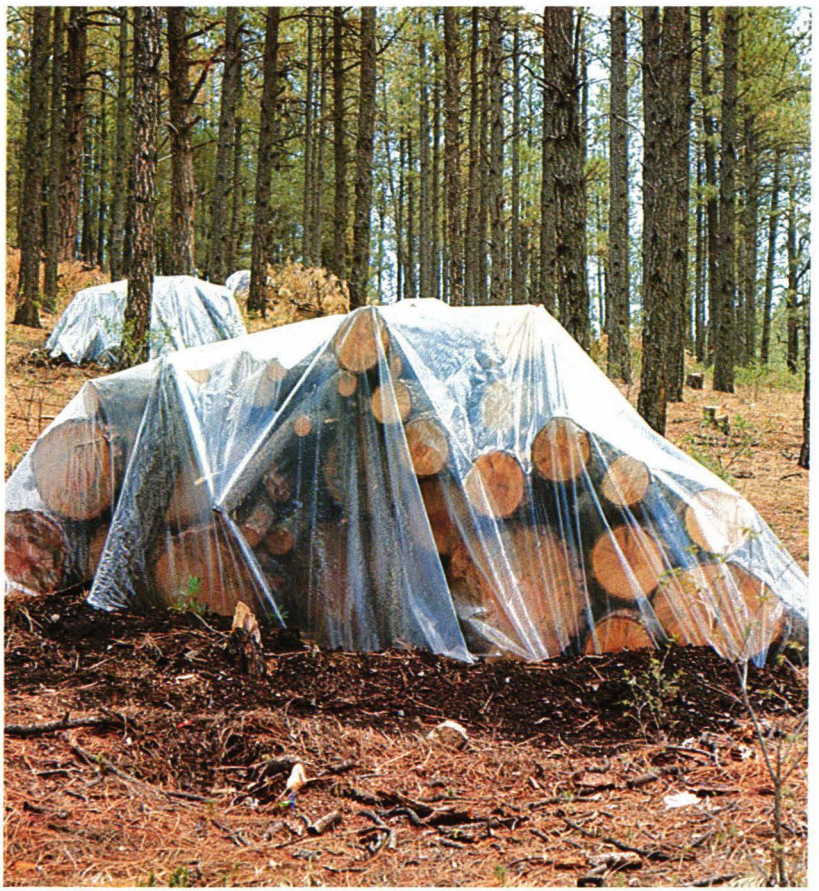


Fig. 10.—Covering slash with clear plastic will kill beetle broods.

3. *Use of Insecticides.* Lindane products are registered for bark beetle suppression. Suppression can be achieved by applying the insecticide to infested slash (4 inches d.o.b. and larger).[1]

4. *Removal of Infested Slash.* Infested slash can be removed 3 or more miles from ponderosa pine forests to prevent the loss of high-value trees from emerging beetles. The public should not be encouraged to collect infested slash for firewood. High-value ornamental trees can be killed by beetles emerging from slash.

Summary

Close coordination between the forest manager and an entomologist is needed to reduce tree losses caused by the Arizona five-spined ips. Forest managers must realize that outbreaks can significantly affect immediate and long-term forest management objectives and take the necessary steps to prevent tree losses. The role of the entomologist is to advise the forest manager. The forest manager uses this information, in addition to inputs from other specialists, to determine management programs and directions.

Entomological assistance can be obtained from the following organizations:

Federal and Indian Lands:

USDA Forest Service
Forest Insect and Disease Management
517 Gold Avenue, SW
Albuquerque, New Mexico 87102
Telephone: Commercial (505) 766-2440; FTS 474-2440

State and private lands:

Arizona State Land Department
1624 West Adams
Phoenix, Arizona 85007
Telephone: (602) 255-4633

New Mexico Department of Agriculture
P.O. Box 6
Albuquerque, New Mexico 87102
Telephone: (505) 766-3914

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[1]This guide suggests the use of an insecticide. All insecticide containers carry a label that describes methods of use and required safety precautions. The material suggested is safe, but read the entire label on a container and follow the directions.

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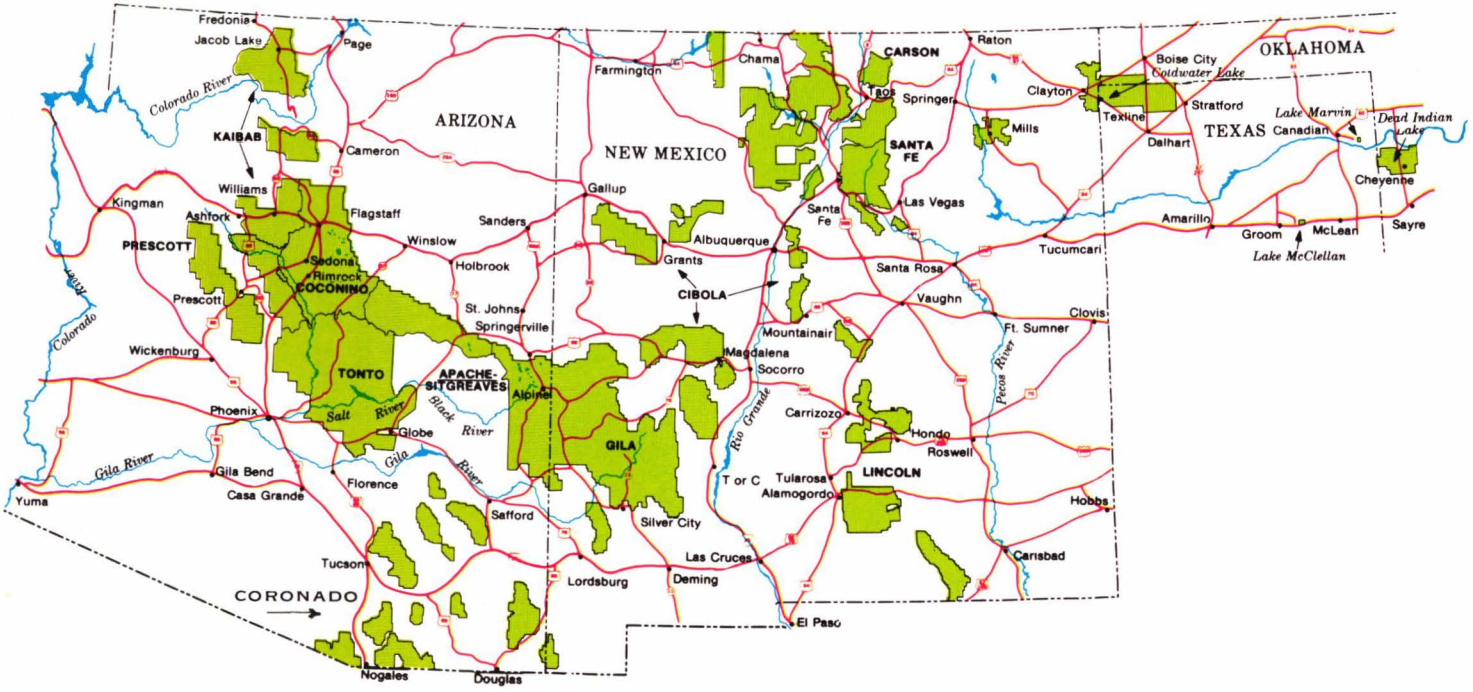
National Forests in Arizona and New Mexico



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